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INVESTIGATION ON INFLUENCE OF ELECTRIC DISCHARGE MACHINE PROCESS PARAMETERS ON MATERIAL REMOVAL RATE OF ALUMINIUM ALLOY PLATES

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ABSTRACT

In the machining of aluminium alloy, the complex components with better metal removal rate is the main aim of the designers and manufacturers. Electric discharge machining (EDM) process is one of the best process to cut aluminium alloys. In this study, the experimental plan was designed according to Taguchi experimental design and L9 orthogonal array was used to conduct the experiments by considering electrical discharge machine process parameters like pulse in time, pulse out time and input current. Analysis of variance method was used to find the significance of every process parameter on material removal rate. The results indicate that pulse on time parameter is the most important factor influencing more on the metal removal rate followed by pulse off time and input current respectively.

KEYWORDS: Aluminium alloys, material removal rate, Taguchi method, orthogonal array.

1. INTRODUCTION

Wire Electric Discharge Machining (Wire EDM) is a non-traditional metal cutting machining process is used to cut conductive materials by developing a high temperature by a series of discrete electrical discharges. For the better manufacturing, it is necessary to study the performance output of Wire EDM for material removal rate (MRR), dimensional accuracy, cutting speed, surface roughness. Out of this Wire EDM outputs, the material removal rate is most desirable output to meet the productivity requirements of the mechanical components in industries. The use of aluminium alloys as components provides an optimum solution for weight reduction as they have a high strength to weight ratio property and leads to overall weight reduction of the body components in the aerospace and automotive structures. Al7075 is a high strength aluminium alloy with the combination of zinc as the primary alloying elements and holding a high strength property. Some investigators were conducted machining with Wire EDM for different kinds of ferrous and non-ferrous engineering materials [1-7]. Saurav Datta et al. [8] developed a quadratic mathematical equation to explain the behaviour of input parameters of Wire EDM process. Hewidy et al. [9] established a mathematical model with different Wire EDM machining parameters for the material removal rate output characteristic. Rajurkar and Wang [10] established a thermal model to analyse the wire rupture phenomena on material removal rate output characteristic. Huang and Liao [11] analyzed with the help of grey relational analysis and and found that the wire EDM process is significantly affected by the feed rate for the metal removal rate. Lodhi et al. [12] studied the optimization of machining parameters of wire EDM process while machining of AISI D3 Steel and observed that the discharge current was the most influential factor on the surface roughness. Venkateswarlu and devaraju [13] have reported that the pulse on time is the most influence factor on material removal rate in the Wire EDM while machining of copper. Azhiri et al. [14] performed experimental studies on machining of Al/SiC metal matrix composite material with oxygen gas as a media and results indicated as pulse on time and current are the most influenced Wire EDM parameters. Durairaju et al. [15] analysed the influence of parameters in Wire EDM process while performing machining on stainless steel materials using both single objective and multi objective optimization techniques. The results reveals that the pulse on time is the major dominating parameter in both optimization techniques. The present study is aimed at optimizing the wire EDM process parameters on material removal rate was investigated.

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2. MATERIALS AND METHODS

The base material used in this study was aluminium alloys of Al7075 plates with 12mm thickness. Experiments were conducted on EDCTR-1 Wire EDM machine. The cutting was performed with a brass wire of 0.25 mm diameter. A group of trial experiments were performed to know the important process parameters and also their range on material removal rate. Wire EDM process parameters for the analysis of material removal rate output are selected as pulse on time, pulse off time and input current and their levels are exhibited in the Table 1. According to full factorial experimental concept, there is requirement to conduct twenty-seven experiments for these three parameters and three levels. For conducting full design of experiments, the cost and effort both are going to rise up. In the optimization process, Taguchi suggested a unique design of experiments, which are having a smaller number of experiments in array matrix with combination of the input factors. This orthogonal array helps to find the effect of every parameter on the material removal rate response with nominal number of experiments. The array is selected based on the number of parameters and number of levels. After conducting Wire EDM experiments, results were converted into a signal to noise (S/N) ratio values, these values are used as a measurement for the quality response. In this work, larger the better characteristic was used to maximize the material removal rate response. According to the design of experiments, L9 orthogonal array (Table 2) was selected for three parameters and their levels.

Table 1. Process parameters and levels

Sl. No	Parameter	Units	Low Level	High Level
1	Pulse on time	msec	90	110
2	Pulse off time	msec	50	60
3	Input current	amps	10	14

Table 2. Orthogonal array for input process parameters experimental layout

Exp. No.	Pulse on time (msec)	Pulse off time (msec)	Input current (Amps)
1	90	50	10
2	90	55	12
3	90	60	14
4	100	50	12
5	100	55	14
6	100	60	10
7	110	50	14
8	110	55	10
9	110	60	12

3. RESULTS AND DISCUSSION

The measured values of material removal rate for each experiment and calculated S/N ratio values are exhibited in Table 3. It is observed that the pulse on time, pulse off and input current time parameters are considerably affect the material removal in machining.

Table 3. Experimental results

Exp. No.	Pulse on time (msec)	Pulse off time (msec)	Input current (Amps)	MRR (mm^3/min)
1	90	50	10	6.74
2	90	55	12	5.82
3	90	60	14	7.73

4	100	50	12	8.20
5	100	55	14	10.51
6	100	60	10	10.12
7	110	50	14	12.28
8	110	55	10	15.14
9	110	60	12	16.76

It can be observed that material removal rate increases with increase in pulse on time 90 to 110 msec is due to discharge energy and transferring period of the energy to the electrodes increases with increase in pulse on time, this leads to formation of huge molten metal crater on the surface of the workpiece. Similarly, it is observed that the increase in the material removal rate with increase in pulse off time. On the otherside, material removal rate decreases with increase in input current from 10 to 12 Amps and then increases with increase from 12 to 14 Amps. The increase in input current cause increase in current density leads to increase in spark energy between work piece and the tool. Above 12 Amps of input current, the discharge from the tool is strikes the workpiece surface creates an impact force on the material in molten puddle, results in the ejection more workpiece material out of the crater. Figure 1 suggested that the material removal rate is maximum when pulse on time is at level 3 (110 msec) and pulse off time is at level 3 (60 msec) and input current at level 1 (10Amps).

Table 4. Response table for material removal rate S/N ratios

Process parameters	Level 1	Level-2	Level-3	Delta	Rank
Pulse on time	16.55	19.60	23.29	6.75	1
Pulse off time	18.88	19.78	20.78	1.91	2
Input current	20.09	19.35	19.99	0.74	3

From ANOVA analysis data presented in Table 5, it can be observed that, the significance of input parameters on material removal rate. Pulse on time is the most influencing parameter on wire EDM machining material removal rate performance which is contributed as 86.55%. This is due to increase in each pulse discharge energy with increase in pulse on time leads to high cutting action of the tool, which results an improvement in the material removal rate during machining. The influencing parameter after pulse on time is the pulse off time with contribution of 8.12% and input current is not notable parameter in the wire EDM machining with contribution of 0.36%.

Table 5. ANOVA results

Source	DOF	Sum of squares	Mean squares	F-value	P-value	% Contribution
Pulse on time	2	97.698	48.849	17.48	0.054	86.55
Pulse off time	2	9.170	4.585	1.64	0.379	8.12
Input current	2	0.416	0.208	0.07	0.931	0.36
Error	2	5.588	2.794			4.95
Total	8	112.873				100

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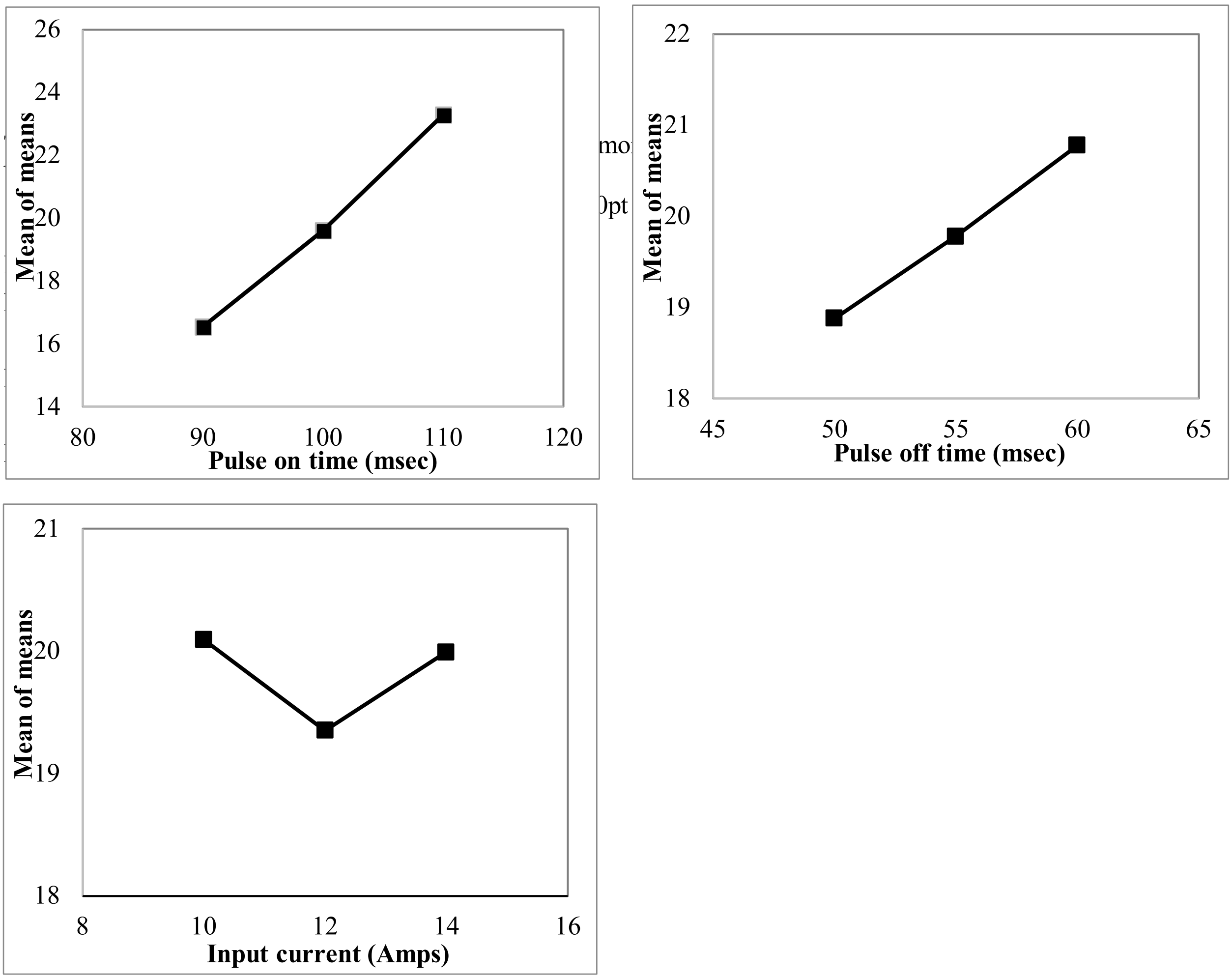

Figure 1. Mean of means of material removal rate

4. CONCLUSION

The influence of Wire EDM process parameters on the material removal rate of aluminium alloy plates were analyzed. The conclusions drawn from this work are as follows. The process parameters were optimized using Taguchi method and optimum values found to be pulse on time is at level 3 (110 msec) and pulse off time is at level 3 (60 msec) and input current at level 1 (10Amps). Pulse on time is the most significant process parameter with contribution of 86.55%. This is because of increase in each pulse discharge energy with increase in pulse on time leads to high cutting action of the tool, which results an improvement in the material removal rate during machining. The second significant process parameter is pulse off time with contribution of 8.12% and followed by input current with contribution of 0.36%.

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